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Network Centric Warfare and the Bandwidth Limited Platform: Beyond the Engagement

by

Charles A. Richard
CDR, USN

A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations

The contents of this essay reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

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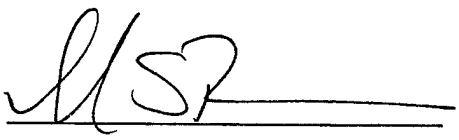
10 May 2000 

D. S. Thompson
Captain, USN
Joint Military Operations Dept

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Network Centric Warfare (NCW) requires high bandwidth in the minds of many. Yet, many fleet units are limited in their ability to communicate. *This will always be the case*. There will forever be forces that are at a relative communications disadvantage to others. It can be shown that a network centric combat force best utilizes the available communications capability of each of its elements, however much or little is available. These benefits can be shown in all areas of the Operational Commander's responsibility, not just the tactical engagement of forces. Operational Logistics is examined in detail as an example of the benefits of networking the operating forces, even those with bandwidth limitations.

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Abstract

Network Centric Warfare (NCW) requires high bandwidth in the minds of many. Yet, many fleet units are limited in their ability to communicate. *This will always be the case.* There will forever be forces that are at a relative communications disadvantage to others. It can be shown that a network centric combat force best utilizes the available communications capability of each of its elements, however much or little is available. These benefits can be shown in all areas of the Operational Commander's responsibility, not just the tactical engagement of forces.

The advantages of a network centric style of operating can be seen in an analysis of the theory of networked organizations. Organization and doctrine changes are required to fully exploit the potential of NCW. Although it is too early to predict the outcome of these changes, some trends are evident. An inspection of these trends shows that none of them precludes participation by a bandwidth limited node, and some of them allow flexibility that can enhance the participation of the disadvantaged user. Selecting organizations and doctrine to allow for the bandwidth limited user also provides other benefits to the network as a whole.

Network Centric Warfare should be deeply embedded in Operational Art, so as to benefit the Operational Commander in every area of his responsibility. However, many writings give the appearance that NCW is focused on the tactical engagement. One useful manner in which to explore NCWs relationship to Operational Art is to use the Operational Functions as a guide for study. Operational Logistics is selected for closer scrutiny in this paper, as this function has the closest parallels to the business world, where much of Network Centric theory originates. These civilian concepts could be implemented rapidly, providing immediate military benefit, and pave the way for more military specific applications of the same technology and concepts. Most of these business concepts allow participation by bandwidth limited users. Three examples are presented.

While much of the promise of Network Centric Warfare employs large amounts of communications bandwidth, it would be premature to "write off" certain types of combat forces in a Network Centric World simply because communications with them are difficult. The process of revising doctrine and organization to both exploit the potential of Network Centric Warfare and allow for the bandwidth limited user should begin today.

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Thesis Statement

"Network Centric Warfare" and "High Bandwidth" are terms that are inextricably linked in the minds of many military professionals. However, many platforms and units are constrained in their communications capacity (bandwidth) compared to others. *This will always be the case.* The armed forces will forever have elements that are at a disadvantage, communications-wise, compared to others. What is the role of the Bandwidth Challenged platform in a network centric world? Can the disadvantaged user participate? The answer is *yes* – The concept of network-centricity, properly executed in both doctrine and organization, makes the best use of available communications bandwidth, however much or little is available. Furthermore, the network centric model is applicable to all of the Operational Functions, not just the engagement of enemy forces as is sometimes thought. In particular, the Network-Centric approach has much to offer when applied to Operational Logistics.

Introduction

The terms "Network Centric" and "Bandwidth" mean many things to many people. To many, Network Centric Warfare requires a large amount of bandwidth. But what exactly is bandwidth? Does Network Centric Warfare (NCW) really require large amounts of bandwidth? What else do military forces do besides engage the enemy? Some brief definitions will be helpful to ensure consistency throughout this discussion.

Garstka, Stein, and Alberts, in their book *Network Centric Warfare* define NCW as "an information superiority-enabled concept of operations that generates increased combat power by networking sensors, decision makers, and shooters to achieve shared awareness, increased speed of command, higher tempo of operations, greater lethality, increased survivability, and a degree of self-synchronization."[1] Note that the term "networking" is used in the definition. "Networking" has many definitions, but two that are applicable are: to interconnect a complex group or system, and to interconnect a system of computers so as to share information.[2] "Bandwidth" is defined as the amount of data that can be transmitted in a fixed amount of time. For digital devices, the bandwidth is usually expressed in bits per second (bps) or bytes per second. For analog devices, the bandwidth is expressed in cycles per second, or Hertz (Hz).[3] "High bandwidth" and "low bandwidth" are relative terms, meant to be used in comparison with each other. The numerical definition of high bandwidth will change over time,

and will depend upon many factors, but 128kbps could be used today as a starting point to discriminate between a high bandwidth and a low bandwidth user.

Network Centric Theory

One avenue to determine if a bandwidth-constrained platform is precluded from participating in a Network Centric force is to examine Network Centric theory and look for bandwidth dependencies and requirements. Admiral Cebrowski, President of the Naval War College and leading theorist on Network Centric Warfare, said that Network Centric Warfare and all of its associated revolutions in military affairs grow out of changes that are dominated by the co-evolution of economics, information technology, and business processes and organizations.[4] In military terms, the co-evolution is in doctrine, information technology, and organization. This co-evolution is linked by three themes:

- The shift in focus from the platform to the network
- The shift from viewing actors as independent to viewing them as part of a continuously adapting ecosystem
- The importance of making strategic choices to adapt or even survive in such changing ecosystems.

He goes on to point out that network centric computing is governed by Metcalfe's Law.[5] Metcalfe's Law was first conceived in 1970 by Robert Metcalfe, the principal co-inventor of the dominant Local Area Network system in use today, Ethernet. Metcalfe postulated that if you connect 'n' number of machines, whether they be computers, telephones, or cars, you get 'n^2' potential value (actually n (n-1), which is approximately n^2 for a reasonably large value of n)[6]. It is this exponential payoff for increasing the number of nodes in a network that is the great source of "power" or "value" in a network style of organization.

Note, however, that Metcalfe's Law is not specifically about computers. Nor is there is a "bandwidth" term in Metcalfe's Law. It does not state that 100 computers interconnected on a very fast network are much better than 100 computers interconnected on a slow network. It is about the power of interconnected machines. The network derives enormous, exponential power from the *number* of potential interactions between its nodes, not necessarily from the *speed* of those interactions.

So where does this association between bandwidth and Network Centric Warfare originate? It originates because Metcalfe's law is an oversimplification of the dynamics of a network. Clearly, 5 computers connected on a 100 Mb/sec Ethernet LAN have more potential value than 5 Morse code operators connected on a pair of copper wires. A more thorough examination of the attributes of a network can show the potential impact of limiting the speed of interaction between its nodes, or, stated in another way, what will happen if bandwidth limited platforms attempt to participate in a Network Centric organization.

There are a number of key attributes that can affect the potential utility of a network. They can include[7]:

Timeliness of Information Transport	Full or Half Duplex
Availability (24x7)	Audio Capability
Search and Navigation	Multiple-Actor Interaction Capability
Service Reach	Visual Capability

Each of these attributes affects the "value" of each of the potential interactions between the nodes in a network. It is a complex process to determine the "value" of network interactions, and it is the users of the network who ultimately define that value. In general, however, the more attributes like those listed above or the better the capability in a given attribute, the more potential value in a network interaction. To obtain more attributes, or more capability in an existing attribute, a network requires more bandwidth. For example, exchanging full duplex video, such as a Video Teleconference, requires several orders more magnitude of bandwidth than does exchanging text email. Alberts, Garstka, and Stein, in the book *Network Centric Warfare* go on to point out that "The capabilities enabled by the [World Wide] Web (i.e. the Internet, one of the largest networks in operation today) represent an order of magnitude increase in the ability of humans to operate in the information domain."[8] They can make this statement because the Internet can have all of the attributes listed above, but to do so requires a relatively high bandwidth network to allow it. It is this second order relationship between bandwidth and the value of an interaction in a network that is the source of the notion that network centric warfare *requires* high bandwidth in the minds of many.

However, a low bandwidth node is not completely without any of the above attributes. Some attributes may not be available, such a visual capability, and some may be degraded, such as timeliness or availability. Yet, the low-bandwidth user can share many qualities listed above. There is no bandwidth threshold for entry onto the network, only bandwidth thresholds for full exploitation of the network. By placing a bandwidth limited user in a network configuration, that user benefits from the greater number of potential interactions now available to him compared to before. This user still benefits from Metcalfe's law and the power of the network, even if he is unable to completely maximize the potential value of each of those interactions. If any communications are possible, there is value in those communications, and Metcalfe's law will apply, therefore, there is no bandwidth threshold for entry onto the network. Communicate faster, have more bandwidth, more attributes become available, potential value of network interactions increase, Metcalfe's law exponentially multiplies these higher value interactions, therefore, network power will increase rapidly. Hence the statement that there are thresholds for full exploitation. Whatever the bandwidth available to the user, however, it is the power of Metcalfe's Law that makes it best utilized in a Network Centric environment.

An analogy illustrates this point. Consider a high-speed railway network that has the ability to directly interconnect a number of nodes needing transportation between them. The ability to rapidly transport items directly to the destination requiring them is a big advantage to the nodes participating in this rail network.

Now consider another location, not on this rail network, that has items for exchange with destinations serviced by the high-speed network. Assume it has no rail connectivity with the fast network, and instead is forced to use lower speed trucking over unimproved roads to exchange items with the closest available node in the high speed rail network. Not only does it suffer from delays in transportation to the high speed network because of the reduced speed available to it over the unimproved roads, it also suffers additional difficulty when the cargo has to be removed from the trucks and repackaged in the proper form for rail shipment. The repackaging adds additional time, and increases the chance for loss of cargo or improper routing to the final destination. The "repackaging" is analogous to having to reformat the mostly text based, alpha-numeric methods of

addressing and delivery of communications to low-speed users typically used today, compared to the embedded, automated style that is used most network protocols in a Network Centric Environment.

Now, provide the remote site with a low-speed railway link to the other nodes in the network. Even if the traffic on this rail line moves at the same average speed as the truck based road that it replaced, the ability to interact directly with the intended destination results in better cargo throughput, and a greatly reduced probability of error in delivering the cargo to its proper destination. The advantages of no longer having to repackage and readdress the cargo upon first arrival at the network also contribute to the value of the low-speed rail connection. The remote site is better served as a member of the network, even if limited in its ability to fully participate.

Another example of this effect can be seen in the evolution of delivery of email to sailors aboard submarines. Initially, personal email from sailors aboard submarines was transmitted by a dedicated, non-networked data link (Battle Group Information Exchange System, or BGIXS) to the carrier, where it was manually transcribed into the network, and then transmitted to its destination. The time from drafting to delivery was measured in days, and was labor intensive. Where submarines can directly access the network, as they can in some situations today, the delivery time is measured in hours or minutes and the manual labor required is greatly reduced. Similar examples and improvements can be shown for tactical systems.

Organizational characteristics of Networks

In order for a bandwidth limited platform to participate in a Network Centric organization, it must be more than just theoretically possible. The organization of the network must be built to allow the bandwidth limited platform to participate.

Many authors have noted that the full effects of the transition to a Network-Centric style of operating are just beginning to be felt. The complete transformation will involve more than just equipment; there will be changes in organization and doctrine to fully exploit the potential of the network. Alberts, Garstka, and Stein point out that "As such, we cannot simply apply new technologies to the current platforms, organizations, and doctrines of warfare."[9] The risk that in developing the new organizations, selections will be made that could preclude the participation of the bandwidth limited node in the network.

It is too early to assess what the eventual organization structure or doctrine of a Network Centric force will look like. However, several emerging characteristics of network centric organizations have been noted to date. They take advantage of the networks near simultaneous ability to communicate point to multi-point, vice heiracheral organizations requirement to operate point to point. Networked organizations tend to be flatter, with fewer 'levels' and with each level having a wider span of control. They take great advantage of the characteristic of networks in that they do not require members of the organization to be co-located either in space or in time. They also fully exploit the tremendous speed of access to information afforded by the network.[10] These characteristics can provide clues as to how a bandwidth limited platform might participate in this type of military, and also provide considerations that could be factored into future doctrine and organizations to allow the participation of the inevitable disadvantaged user.

A technical characteristic of networks is their ability to communicate point to multi-point vice point to point. Related is their ability to conduct simultaneous interactions between nodes. This comes from the protocols used in most network installations, e.g. Transport Control Protocol/ Internet Protocol (TCP/IP). This is in effect a form of time-division multiplexing, and both characteristics benefit the bandwidth-limited participant. As noted in the analogy above, once the data from a limited user is on the network, the network handles the routing to multiple destinations. This frees the limited node from having to send the same data multiple times, and allows leveraging of higher bandwidth connections inside the network. The ability of a node to execute simultaneous interactions is of great benefit to an intermittent access user. Once access is gained, there is no delay or need to preempt other nodes accessing a given point. It is true that some bandwidth-limited platforms would benefit in some situations from an ability to receive a priority driven bandwidth reallocation, but the built in ability of a network to handle multiple interactions makes it much easier to receive and act on this request. These two technical characteristics, point to multi-point and simultaneous interaction capability, both benefit the bandwidth-limited participant and are advantages of adopting a Network-Centric style of operating.

To date, most of the implementation of IT into military forces has been to overlay the new technology onto the existing organization and doctrine. What results are electronic versions of the

previous paper and voice styles of operation. This is not necessarily bad; in fact it is a reasonable first step and provides benefit due to the greater accessibility of information. However, even more benefit can be achieved once organization and doctrine also co-evolve. One observation that has been made as to the effect of moving to a network centric style of operations is the flatter organization structures that result. Laudon, Traver, and Laudon note a reduction of managers and clerical workers when investment in Information Technologies is increased.[11] While many have noted the need for the military to examine alternative organizational formats, few have ventured specific concepts for analysis. One who has is Admiral W. J. Holland, in his article "Where Will All the Admirals Go?"[12] Here, he postulates a shorter command chain and the elimination of mid-level staffs between commanding officers and top political and military decision-makers. It is reasonable to predict that the first organizations who will be modified or eliminated by advances in Information Technologies will be those whose entire reason for existence is the processing and manipulation of information: the major staff organizations. This evolution is likely to be painful and controversial, primarily due to the politics involved with such changes. However, it is also necessary to derive the full benefits from a transition to Network-Centric Warfare.

In his article, Adm. Holland notes that "major [Naval] campaigns have been fought with widely dispersed forces commanded from fixed headquarters ashore", and he considers the possibility that this style of C2 could become the model for the future.[13] There are several types of bandwidth limited platform that have considerable experience in this style of operating, including submarines and maritime patrol aircraft. Proven procedures exist for this style of operating, and if the entire force was to be commanded from shore through very short and direct chains, integration of these previous "special cases" could become easier. Part of the reason for this is the greater accessibility by the Force commander to platform-unique information that is necessary for employment but difficult to obtain directly from the unit if it is bandwidth-limited. No matter what organization finally results, however, the key to employment of these bandwidth-limited platforms is access to this platform specific information. This can be achieved by geographic co-location ashore, high-bandwidth shore or sea based links, or assigning platform-experienced personnel to the commanders staff. Network centric

organizations have better potential to organize themselves to fully exploit the capabilities of a bandwidth-limited participant.

Both the lack of a requirement for geographic or temporal co-location and the speed of access to information inherent in a network centric organization benefit the bandwidth-limited user. The networks ability to store information and make it available on demand is a particular advantage to intermittent access nodes, who have a wider latitude to connect into the network when it is tactically advantageous or allowable. Once connected, the greater speed of access to information helps minimize the bandwidth required to conduct the exchange.

Therefore, none of the four observed characteristics of network centric organizations preclude participation by a bandwidth-limited platform. In fact, the flexibility in organization allowed by a network in general benefits the limited bandwidth user. Future organization and doctrine could allow for the participation of the disadvantaged user. However, to be complete, it is necessary to distinguish two different types of bandwidth limitations and to individually assess the potential issues associated with each.

Types of bandwidth limitations

There are two different, but related forms of bandwidth limitations that should be considered when developing organizations and doctrine for Network Centric Warfare. The simpler of the two are bandwidth-constrained platforms and units. These may enjoy continuous or near continuous access to the network, but are limited in the speed at which they can transfer data. The second, more difficult problem is that of intermittent access, where the node may be only able to connect to the network occasionally, or is forced to limit itself in some fashion while communicating. A platform can be both bandwidth limited and only have intermittent access. These limitations are not unique to the military; they have been encountered in the private sector as well. Nor are they unique to a network centric military force. Many older Command and Control arrangements have encountered similar obstacles. Both groups' experiences provide methods to minimize and overcome these limitations in a Network Centric force.

Bandwidth constraints on users with long-term access have less impact on participating in Network operations. The key for their participation becomes the most efficient utilization of the

available bandwidth. Network routing schemes can be established that only require the exchange of data with the closest high-capacity node, which then takes over responsibility for routing data to multiple subsequent recipients. Maximum utilization of data storage capability aboard the remote platform becomes important. The price and size of mass data storage has been falling proportional to the changes seen in other areas of IT equipment. It is now possible to receive and record huge quantities of information from military networks (e.g. the SIPRNET) when conditions permit. For example, a ship could "pull down" all of the SIPRNET web sites of interest while pierside and connected to a high bandwidth fiber connection. This would eliminate the need to transfer background, reference, and background user-display graphic information while at sea using lower bandwidth connections. Only updated or changed information would then need to be exchanged. Network management tools can be used to schedule and prioritize information exchange tasks, with the goal of ensuring full utilization of the available bandwidth and minimizing idle periods. Text based formats can be substituted for graphics intensive applications if necessary. If high-bandwidth access is intermittently available, it is used to the maximum extent possible to minimize requirements later. Finally, processes are examined to eliminate redundancy in data transmission, so that data is only transmitted once, and higher capacity facilities perform any additional required formatting and delivery.

Intermittent access is the more difficult limitation to overcome. It is useful to provide these nodes with as much bandwidth as possible, so that they can take maximum advantage of communications opportunities. In addition to the techniques discussed above for bandwidth-limited platforms, intermittent access nodes could benefit from new technologies being developed in the commercial world. For example, XcelleNet, a private U.S. firm, is developing RemoteWare, a software application that enables remote, intermittent access business operations to continue independent of events at the corporate headquarters. Called Queued Event Architecture, it enables both the headquarters and remote user to access and manipulate local copies of a common database.[14] Once a connection is restored, it synchronizes and updates all transactions on both the local and remote data base copies. Note that only changed events require communication, not the database as a whole. Another, more common example is the synchronization function built into most World Wide

Web browsers, such as Microsoft's Internet Explorer. A remote user can designate web pages (e.g. SIPRNET sites) that he wishes to be made available "off line". After an initial download, the remote user can schedule, either manually or automatically, updates to the stored pages. Only changed information is retrieved, minimizing the bandwidth required to synchronize.

Another technical approach to overcoming bandwidth limitations involves leveraging the wider availability of information processing capability now available. One application of this could be found in participation in the "sensor grid" of the NCW model. While the optimum level of participation may be for all sensors in the grid to exchange raw data, bandwidth constraints may not allow this. However, by leveraging local processing capability, the raw data can be converted into information that has a good probability of providing added value to the network as a whole. Local processors and operators evaluate the incoming data, and pass along only that information which contribute to enhancing the common operational picture. This processing and filtering function reduces the bandwidth required, and allows some degree of participation in the grid.

Beyond technical considerations to bandwidth limitations lie organization and doctrine considerations. One of these involves the recognition that in some cases, no information is in fact information. This approach has particular merit for stealthy platforms, particularly those who can communicate as desired, but give up tactical advantage to do so. It has long been applied in submarine operations, and has been found useful for stealth aircraft. In essence, once a task has been assigned, the lack of further reports from the platform is taken as a report that conditions are satisfactory. Communications are established only when events require a revision to the desired sequence of events or for a major update to the common operating picture. While none of this is new, the concept is still very useful in a Network Centric Environment. In fact, as it becomes more difficult to gain access to contested areas, such as the littorals, it may become necessary to apply elements of it to platforms that to date have not utilized it. For example, by providing a one-way "broadcast" flow of the operational picture to a surface unit operating in close proximity to a hostile shore, and allowing the ship to minimize its transmissions could help improve its resistance to shore based targeting.

There is a final reason to ensure bandwidth limitations are considered in developing the organization and doctrine for a Network Centric Force. The article "Beyond the Rose Colored Glasses" published in the February 2000 Naval Institute Proceedings discusses the vulnerabilities that exist in some of the high-bandwidth circuits currently in use today.[15] "The disruption of key network nodes and links through physical destruction, denial (jamming), or intrusion could isolate whole segments or theatres..."[16] Shannon's Law states that higher bandwidth signals require greater signal to noise ratios for transmission, which in turn is easier to disrupt or deny.[17] The utilization of non-hardened commercial circuits tends to increase this vulnerability. By designing networks to allow the participation of the disadvantaged user, a built in fall back mode is developed which can be used by nodes in the network who have been denied their normal high-bandwidth access.

Beyond the Engagement

Many of the models and scenarios used in discussions of Network Centric Warfare give the appearance of being focused on the engagement. The concept of a sensor grid – information backplane – engagement grid tends at first look to fit the tactical engagement more readily than it does the higher operational level of war. Yet, to be useful, Network Centric Warfare must be applied at the Operational and Strategic levels of war. There are many that have seen the potential of a Network Centric approach at the Operational and Strategic levels. Alberts, Gartska, and Stein note "To reach its full potential, Network Centric Warfare must be deeply rooted in operational art."[18] One model of operational art, a model of what the Operational Commander must do to accomplish strategic objectives in a given theatre of operations is called the "Operational Functions". Dr. Milan Vego of the Naval War College writes "The establishment of a theatre brings into existence theatre-wide "functions" that allow the operational commander the wherewithal to plan, prepare, conduct, and sustain military actions across the full range of military operations (RMO)."[19] There is no jointly agreed list of these functions; however, there are several that can be differentiated. They include Command and Control (including the sub functions computers and intelligence "C4I" and Information Operations), Operational Intelligence, Operational Fires, Operational Protection, and Operational Logistics.[20] Network Centric Warfare has applicability beyond the engagement. It has applicability and impact to all of these functions. In fact, Network Centric Concepts that are

borrowed from the business community have their most direct applicability to Operational Logistics. These concepts do not necessarily required high bandwidth, and in many cases can be implemented faster than those related to military specific tasks. An examination of the potential benefits of a Network Centric approach to operational logistics will show what could be accomplished today, with minimal bandwidth, and without detracting from the tactical war-fighting applications of the same concepts.

Logistics functions required to support naval forces

Naval Doctrine Publication 4, *Naval Logistics*, broadly defines naval logistics as *products* provided to the end user – equipment, supplies, facilities, services, and trained manpower; and *processes* used to provide and maintain those products – production, procurement, distribution, training, and maintenance.[21] Six broad functional areas are defined: Supply, Transportation, Maintenance, Engineering, Health Services, and Other Services (including Personnel Administration and Pay Disbursing).[22] NDP 4 goes on to note that the processes used to execute the functions described above require redundant and reliable communications, and that the amount of information required to accomplish it is large and diverse.[23] It is in this logistics command and control area where significant potential for improvement by the application of Network Centric concepts lie.

Potential Concepts in applying Network Centric Technology to Operational Logistics

There are several theoretical concepts related to a network centric style of operating that can be used as guides to exploring potential improvements in the ability to provide logistics support to deployed forces. They are also useful in examining the impact of limited bandwidth on a participant in a Network Centric force. By taking advantage of the attributes of network centric organizations, including the ability to communicate point to multi-point, the improved speed of access to information, and the elimination of the requirement for geographic and temporal co-location of personnel, new opportunities for improved logistics support become possible.

One concept for examination involves ensuring each piece of logistics data is only transmitted once from the mobile platform or unit. The current method of providing logistics support to combat units has evolved into a highly vertically integrated, specialized organization structure. Intermediate and Depot Level Maintenance, Supply, Personnel Support, and Utility support all operate in separate

chains of command and do not fall under the responsibility of Operational commanders until senior levels of the chain of command are reached. This organization structure provided the benefit of economy of scale and focus, particularly given the constraints in place when many of these organizations were formed in the past. Each supporting organization tends to optimize the data flows into and out of itself so that it can best accomplish its assigned tasks. One unintended consequence of these specialized communications requirements and formats is the accumulation of overlapping and redundant data transmission requirements on the units being supported.

For example, consider a small combatant ship that suffers a significant mission degrading material casualty while at sea. The casualty will affect the ship's ability to carry out its mission, and requires parts and external support to correct. Today, several different text based messages are required to be sent. As it is mission impacting, a Casualty Report (CASREP) is required to report the loss of capability and impact on the assigned mission to the operational chain of command. Since parts are required, a MILSTRIP requisition message will have to be sent (either in automated electronic or text form) to obtain the necessary parts. As external maintenance support is necessary, a message work request (OPNAV 4790/2K, message format) has to be prepared. Finally, the event will also probably be reported more informally in various operational and material status messages until the situation is resolved.

There is tremendous overlap in the data contained in the above messages. In fact, since many are manually or semi-automatically prepared, it is necessary to *manually* cross check the messages to ensure consistency between all of them. Substitution of one for the other is expressly prohibited in many of the governing instructions. What happens, in effect, is the unit needing the support is forced to organize the outgoing data into formats that are most efficient to the supporting organizations. Failure to do so risks being denied the necessary assistance, and consequent impact on mission capability. This data-organizing task falls to the group with the least resources to accomplish it, and detracts from the ship's ability to actually accomplish the repair. More over, the necessary bandwidth for communication has been multiplied by about 400%, as each function specific format is separately transmitted.

In a Network Centric environment, events such as the above could be analyzed in the entirety, instead of down functional logistics support lines. The total quantity of data required from the ship can be determined, one message could be transmitted, and the power of rapid network access to information could be applied to reformat and distribute the data to supporting organizations needing it in precisely the optimum format they desire. Not only have communications and bandwidth requirements been reduced, but also inconsistencies and errors can be minimized, speed of transmission improved, and less time is required to obtain, format, and transmit data. "Each piece of data leaves the ship once" could be used as one of a guiding set of concepts in improving logistics support.

Another possible area for exploitation is the lack of a requirement for geographic and temporal co-location of logistics personnel. One of the reasons for the vertical integration of logistics functions described above is the unfeasibility of many mobile platforms to carry the personnel and facilities necessary to provide logistics support. New organization structures can be developed where supporting personnel are "virtually" integrated into lower levels of the operational command structure. Individual ships and aviation squadrons, or their immediate supervisors, could be given more direct command authority over supporting personnel and facilities. Dr. Vego notes "Logistics is one of the principal responsibilities of the operational commander and staff. Often commanders and their staffs think that their staff or supply officer should have the major responsibility for logistics, when in fact it is the operational commander who must apply the available logistical resources to generate and sustain theatre combat power."[24] The improved ability to interact afforded by networks could produce new organization model that better allow the operational commander to exercise this responsibility. It could help overcome the difficulties associated with the often-necessary geographic and temporal separation of the operational and supporting units. Commanders can benefit from improved responsiveness of logistics support, and logistics units can receive better information as to exactly what is required where, and when it is needed. It could even be possible at some point to establish "virtual crews", personnel assigned in supporting roles to individual ships, responsible to the ships CO for the services and support that they provide, directly linking logistics support to the combat elements needing it.

Commercial Examples

More so than any of the other Operational Functions, the experience of the private business community in developing Network Centric concepts is applicable to Operational Logistics. It is not difficult to think of commercial firms engaged in the same logistics functions as described in NDP 4. Not only are the functions the same, but they are often striving to achieve the same qualities as those desired by the military: Responsiveness, Simplicity, Flexibility, Economy, Attainability, and Sustainability.[25] Only the quality of Survivability could be considered somewhat unique. Additionally, many private firms are executing network centric styles of operation today, and their experiences provide opportunities to examine potential applicability and utility for military uses. Three examples of commercially available, network based, logistics capability that are widely available and in use today show the potential impact of networking to the Logistics function.

Three Logistics Examples

Federal Express is the world's largest express transportation and surface expedited cargo carrier, and the second largest provider of ground package transportation services in North America.[26] FedEx handles more than 100 million electronic transactions a day and invests about $1.5 billion each year in the best Information Technology equipment and personnel. FedEx leverages the power of networks to combine visibility and velocity to achieve this level of success. It is possible to go to the Federal Express World Wide Web site and determine the exact shipping status of most of the packages in transit in their system (Figure 1). It is highly accurate, and very detailed. You know where your package is (i.e. At Philadelphia International Airport awaiting ground transportation, expected departure AM 4/27, expected delivery AM 4/28). If the user does not have sufficient bandwidth to support a graphics based access to the Internet, it can also send an email with a text-based version of the above information. This enables them to service mobile users equipped with nothing more than an Internet capable cellular phone. FedEx claims to have reduced the amount of time companies spend shipping an average of 40%. Not only would an equivalent reduction significantly aid the operational commander, but also simply having accurate status and delivery information even without benefit of improved delivery times would be of enormous value. In many cases today, operational planners are significantly handicapped by the uncertainty in delivery

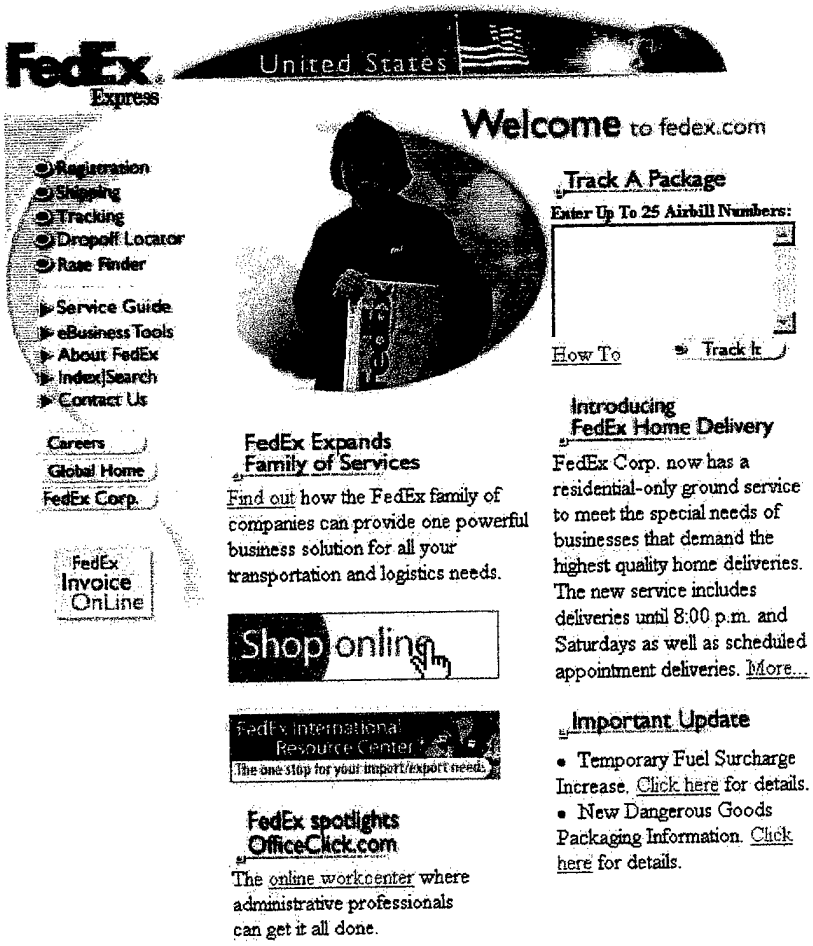

Figure 1
Federal Express Corporation
Package Tracking Services

schedules for supplies. At a minimum, this capability should be available today for high priority requisitions necessary to restore units to full combat capability.

Dell Computer Corporation is the world's leading direct computer corporation.[27] The firm boasts a superlative ability to support its products after they have been sold. KPMG LLP, the accounting, tax, and consulting firm, honored Dell Computer Corporation with a 1999-2000 KPGM High Tech Award. Support.dell.com received the Industry Leadership Award for companies with more than 200 employees, and Dell credits this ability to support its products as a major reason for its overall success. Any owner or user of a Dell computer can go to the Dell Support site on the World Wide Web, enter the custom system tag for the system, and receive a complete support package tailored specifically to that machine. Purchase date, warranty information, full system

Figure 2
Dell Computer Corporation
Internet Based Support Page

documentation, all applicable service notes, all available hardware upgrades, and access to a complete library of available software and driver updates are provided to the user. Upon installation of a software package, remote diagnostics and performance measurement can be performed. Testing results and recommendations for improvement are given to the user on-line, in minutes. Additionally, a searchable database of the results of other users interaction with support technicians is available, helping to minimize the number of times the same problem is resolved on different machines. When all else fails, direct contact with support technicians is provided. All of this is tailored to the specific machine in question. An example of the information available is shown in Figure 2. This capability far exceeds anything available to military technicians and users in the field today. The potential utility

for keeping vital systems functioning at peak performance is obvious. While retrofitting this level of support to the numerous legacy systems in service today would be an almost impossible task, it should be implemented on new systems, particularly C4I equipment.

Many financial institutions today offer a wide array of services to their customers via the Internet. For example, Navy Federal Credit Union and many others provide online account access, ability to transfer funds between accounts, receive and pay bills electronically, and the ability to download account information to personal financial software.[28] Figure 3 is an overview example of Navy Federal's service. Many major investment houses including Merrill Lynch offer the above plus the ability to buy and sell securities and mutual funds, research the performance of a wide variety of financial instruments, and even establish accounts online.[29] Still other sites, such as Quicken.com, can do all of the above and purchase insurance, loans and mortgages, and even provide for data backup.[30] There are numerous applications of this type of technology to the military pay, accounting, and personnel administration functions. The current system is paper-intensive at the user level, often requires physical presence of the service member away from the normal place of duty, and is often time-consuming. Although some initial steps are being taken to eventually allow service members limited remote electronic access to their pay accounts, progress is slow.[31] Ultimately, pay and personnel accounts could be made completely electronically accessible at the operational unit level, enabling timely access to the status of accounts. Qualified unit personnel, with proper controls and supervision, could be given the authority to conduct transactions remotely, removing the need for the physical "brick and mortar" presence of support personnel in the theatre of operations. An interim step could include provisions for operational units to electronically transmit data to existing support organizations, to eliminate the time-consuming requirement of physical presence at the support command. These functions can easily be performed on low-bandwidth circuits. They also do not require the priority or speed of delivery necessary for combat data. One advantage this brings to low-bandwidth, mobile users is such information exchanges can be delayed with minimum impact until access to a higher bandwidth circuit is obtained, such as when a small combatant ship pulls into port and establishes a higher speed hardwired connection to the information grid.

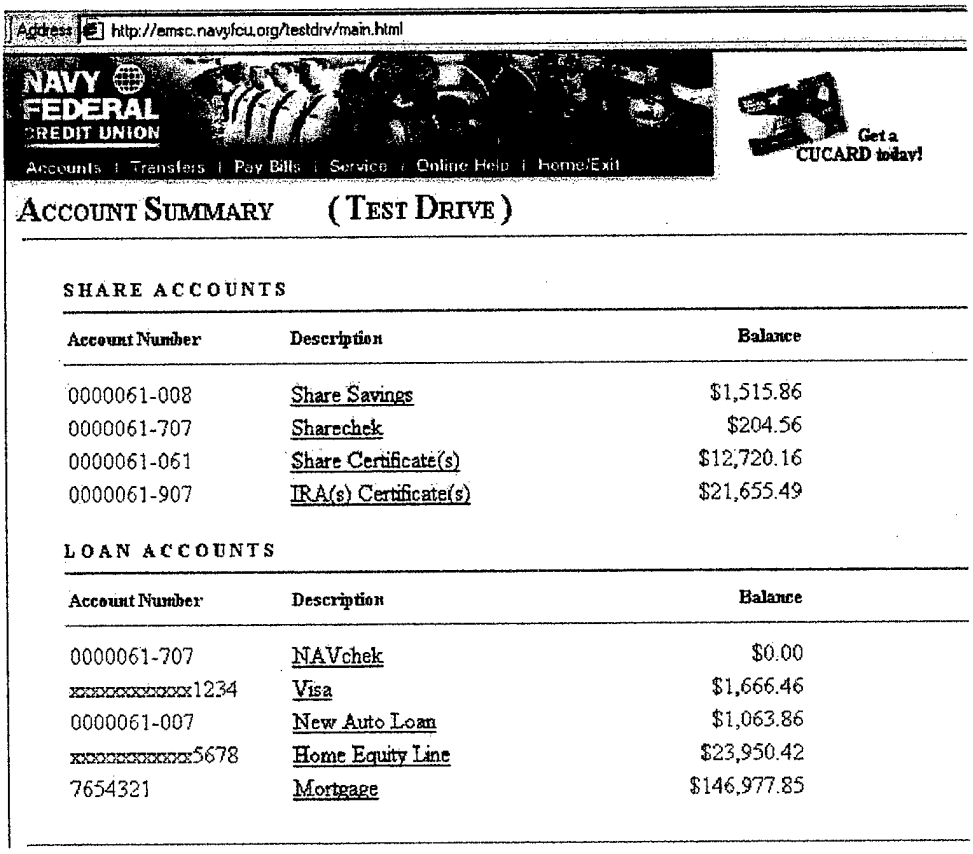

Figure 3
Navy Federal Credit Union
Internet Account Access

There are several key points in common to the three examples presented above. Each of the commercial applications described closely parallels functions required and in use by the military. The task accomplished by FedEx when it transports, tracks and delivers cargo is much more similar to military supply functions than any commercial example is to the military function of fusing data from numerous sensors to form a common operating picture of the air battle in a region. This similarity makes it much more likely that the private sector techniques can be successfully applied by the military. Second, these examples are in use today. The private sector has already expended the effort to develop these capabilities. Many lessons have already been learned. In fact, beyond just borrowing from private industry, many of these functions could exploited by either simply using these service (e.g. some high priority military shipping is already being carried by Federal Express and others), or by contracting the service. In cases where it is not desirable to fully contract out a function, civilian

expertise could be hired to establish the capability and then turn the system to be run by military personnel. Another benefit of quickly leveraging these types of capabilities is that personnel become trained and familiar with the skills necessary to function in a Network Centric Environment. By being exposed to the interfaces and techniques used in a network enabled logistics system, it requires less training to exploit combat applications of the same technology. Finally, as personnel begin to see first hand the power and potential of networked applications, they are better prepared to innovate and exploit network centric capability in ways that have not yet been envisioned.

Conclusions

Like the poor in society, bandwidth constraints on some elements of a military force will always be present. Contrary to current assumptions and practice, this does not preclude their participation in a Network Centric force. In fact, a network centric force is the best choice to accommodate these elements, as a *Network Centric force will always best utilize whatever bandwidth is available.* Properly executed in doctrine and organization, these limitations can be minimized. This does not mean that high bandwidth is not advantageous to the Network Centric force. While there is no bandwidth threshold for entry onto the network, there will be bandwidth thresholds for degrees and quality of participation. Ongoing efforts to improve available bandwidth will pay handsome dividends, and should be continued. However, the disadvantaged user should not be "written off" as these concepts evolve. In particular, the tendency to wait until network access is established, or improved, before determining how to employ it needs to be reexamined. For example, some groups wait until SIPRNET access has been provided to the command before considering what to do with it. This unnecessarily delays utilization of the improved connectivity. By paralleling consideration of how to employ the improved capability with efforts to obtain it, greater benefits can be obtained quickly. These considerations should not overlook logistics, where the civilian sector has provided models that can be quickly implemented for military use, and do not necessarily require large bandwidth. Network Centric planning that includes provisions for bandwidth-limited participants is also useful for developing systems that "fail gracefully" when high-bandwidth circuits are not available or degraded by adversary action. The Network Centric Navy is not about tomorrow, it is about today, and all people and forces in the Navy have a role to play.

Notes

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